

Decoding Phonological Working Memory Load

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Outline

- Statement of Problem
- Hypothesis
- Experiment Design
- Data Analysis
- Results

Statement of Problem

Reading relies on phonological and semantic working memory (Caplan & Waters, 1999).

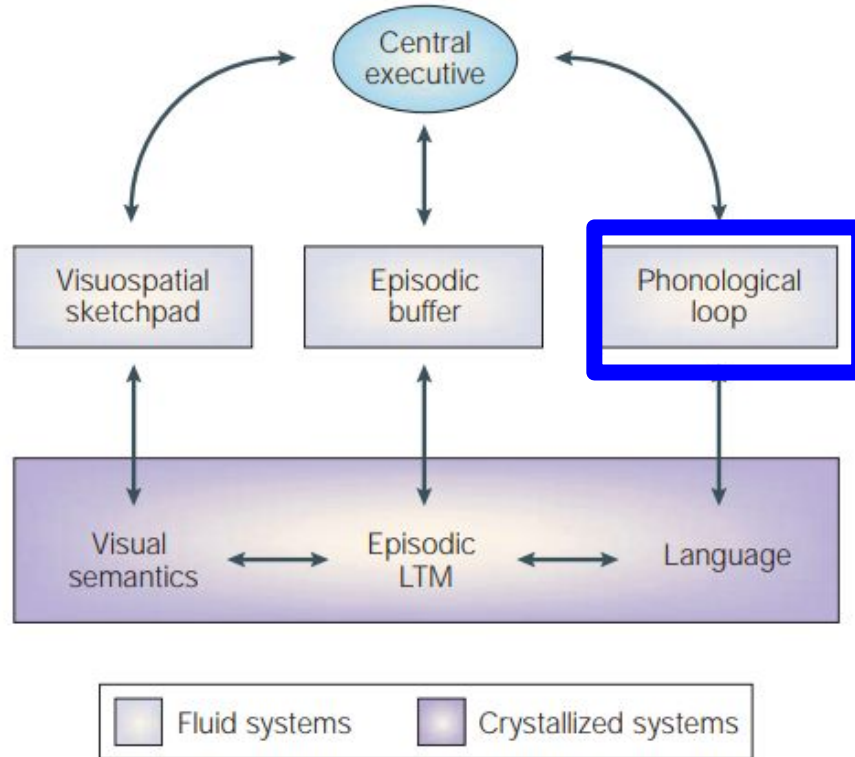
Separating the effects of load in either system would be important for understanding how we read.

For example, when reading becomes difficult due to either the text or the reader, what systems must the reader rely upon to persevere?

Hypothesized process (How it works)

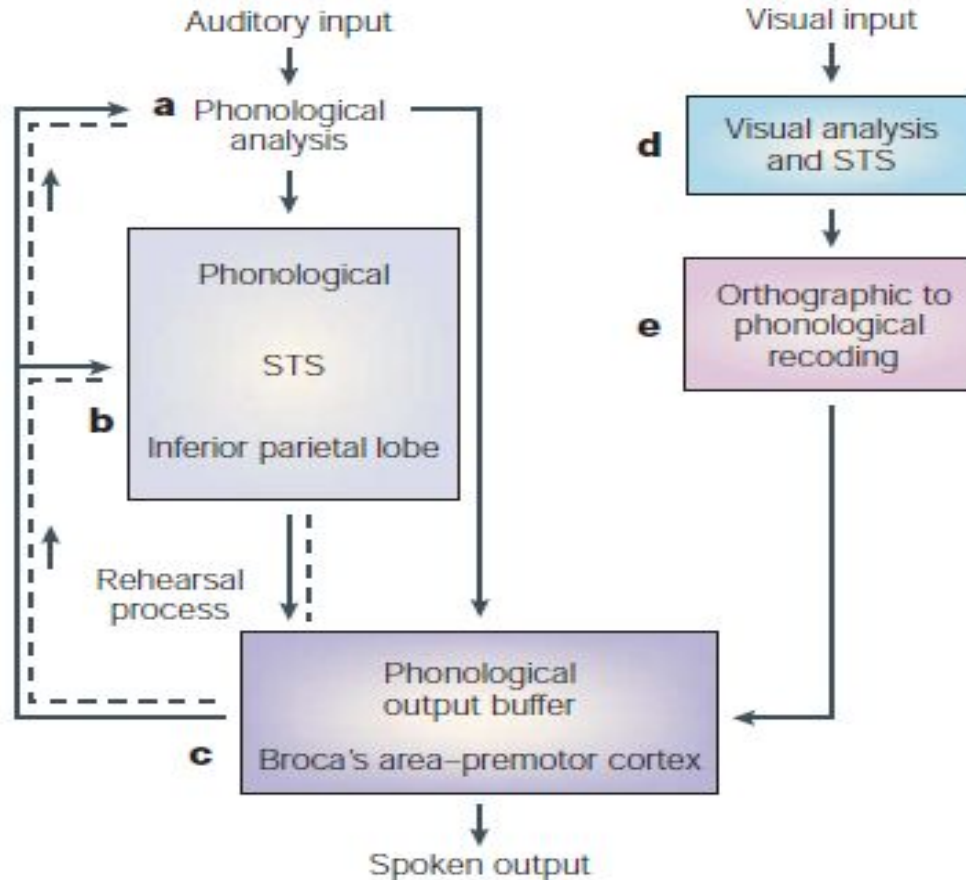
1. Visual words get stored in terms of phonological, semantic, and orthographic representations.
 - a. Tousman & Inhoff, 1992; Besner, 1987; Waters et al., 1992; Perfetti & Hart, 2002; Plaut, McClelland, Seidenberg, & Patterson, 1996.
2. These separate representations are activated to various degrees depending on the task
 - a. rhyme judgment tasks → phonological representations increase (Besner, 1987)
3. These representations remain active during the delay.
 - a. Phonological representations require brain areas which plan articulation (Waters et al., 1992)
 - b. These areas are Broca's area and Precentral Gyrus (Poeppel et al., 2012; Guenther et al., 2009)

The Baddeley working memory model



(Baddeley, 2003)

Functional Model of the Phonological Loop



(Baddeley, 2003)

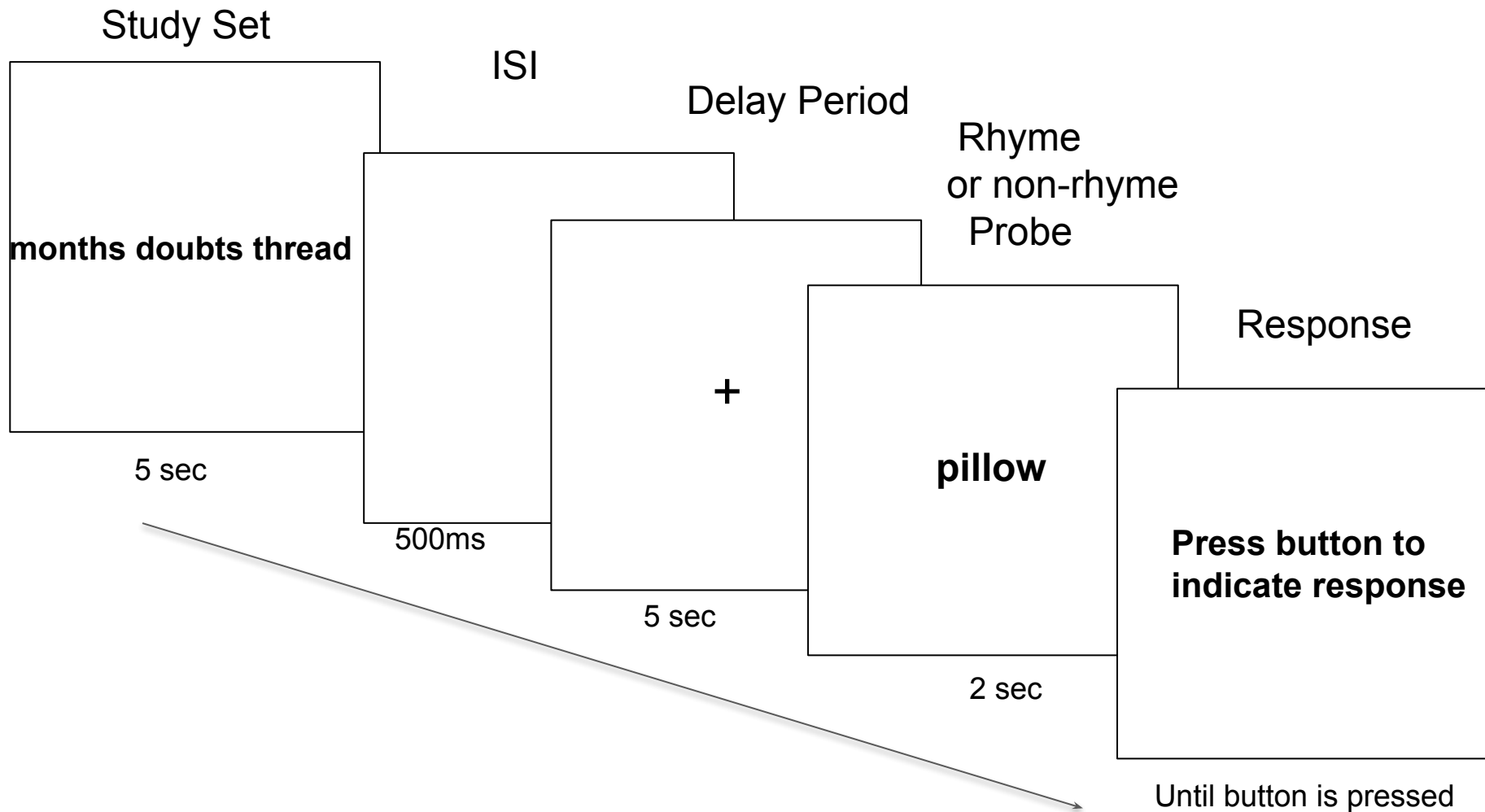
Hypotheses

If phonological loop works as Waters et al. (1992) predict, what will the articulatory rehearsal look like over the delay?

1. Which frequencies will correspond with what areas of the cortex?
 - i. High freqs (Gamma, Alpha): relative local areas of cortex (see Poeppel et al, 2012)
 - ii. Lower freqs (Theta): involvement of subcortical areas/dispersed areas of cortex
2. Will there be differences based on load?
 - iii. In our case, one vs three-syllable lists
3. Will there be differences for words and non words?
 - iv. If words are stored differently than nonwords, we expect different decoding results.

Experimental Design

- Participants
 - 5 native English speakers
 - 1 undergraduate and 4 graduate UMD students
- A phonological working memory task
 - Memorize 3 words/non-words
 - Rhyme or non-rhyme
- Experiment duration
 - 45 - 60 min



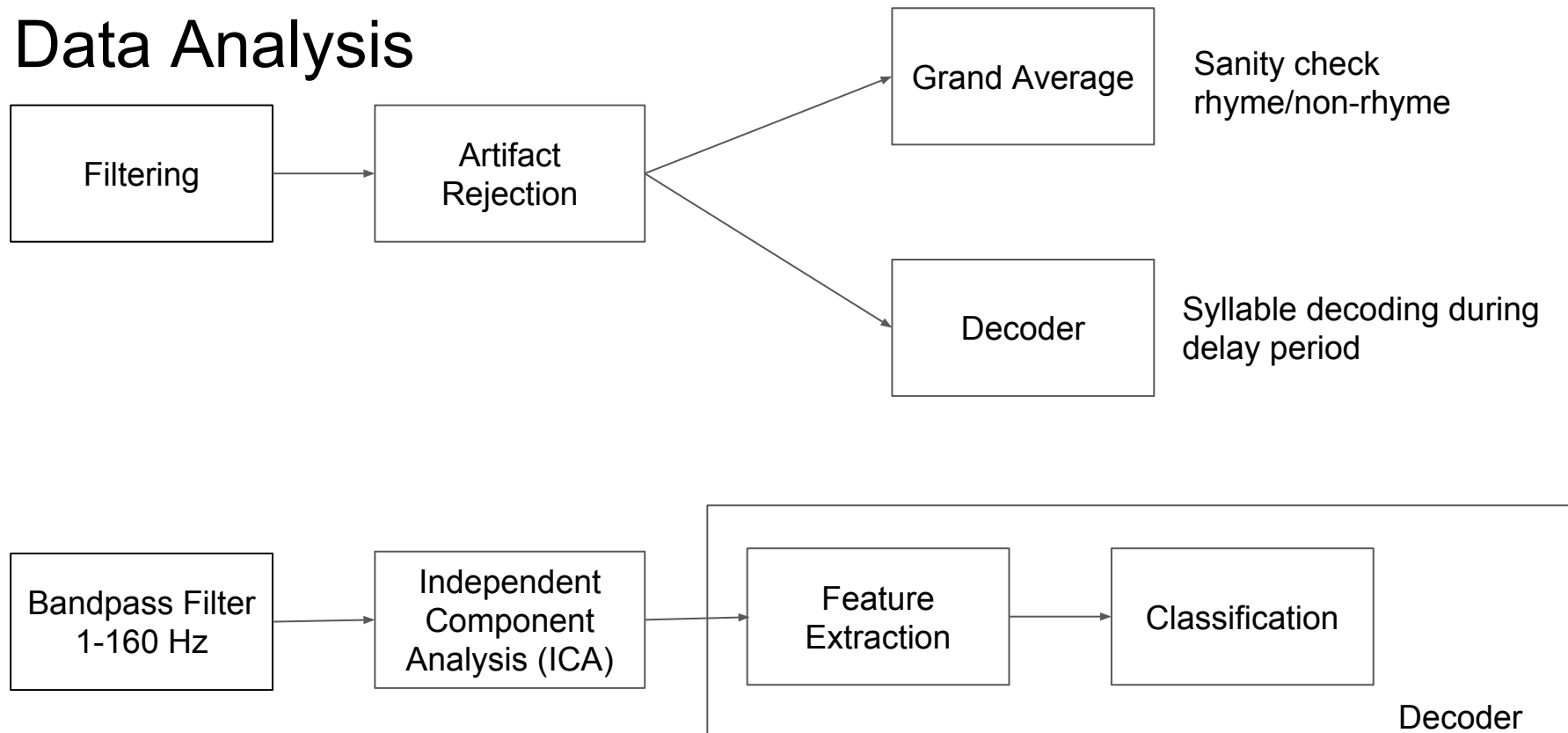
Experimental Design

- 2 (non-word vs.word) x 3 (1,2,3 syllable) design
- 3 non-word/word cluster=1 set
- All words, non-words were 6 characters
- 75 sets of words; 75 sets of non-words

Stimuli

	Words	Non-Words
1-syllable	"nights street clones"	"cooved sirths treeks"
3-syllable	"zodiac lunacy awaken"	"ahousa priary epelid"

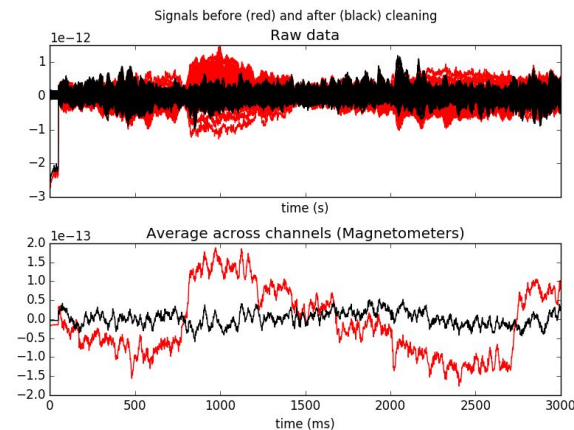
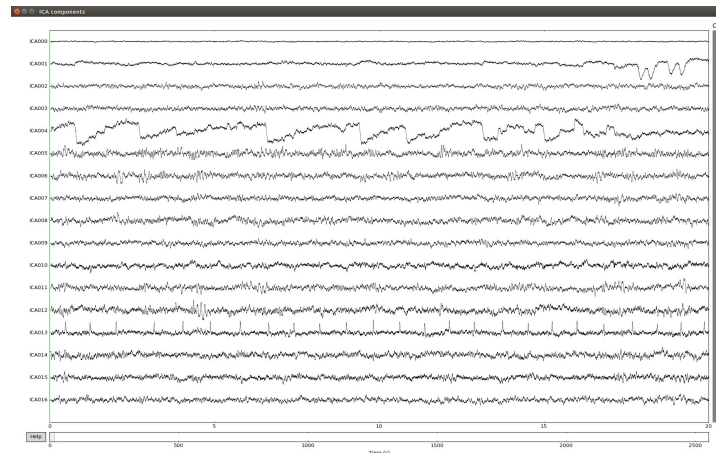
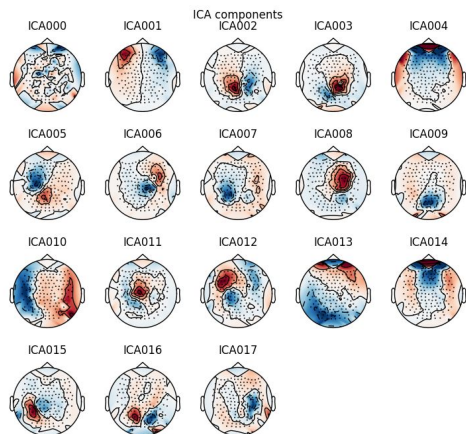
Data Analysis



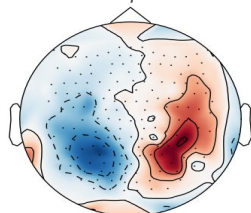
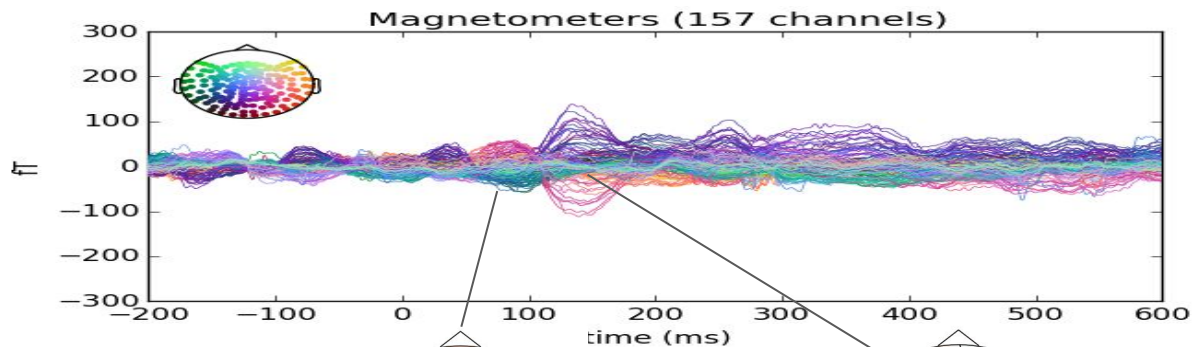
Data Analysis



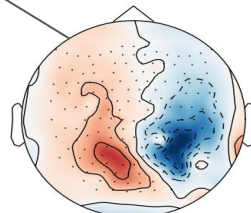
Independent Component Analysis (ICA)



Data Analysis



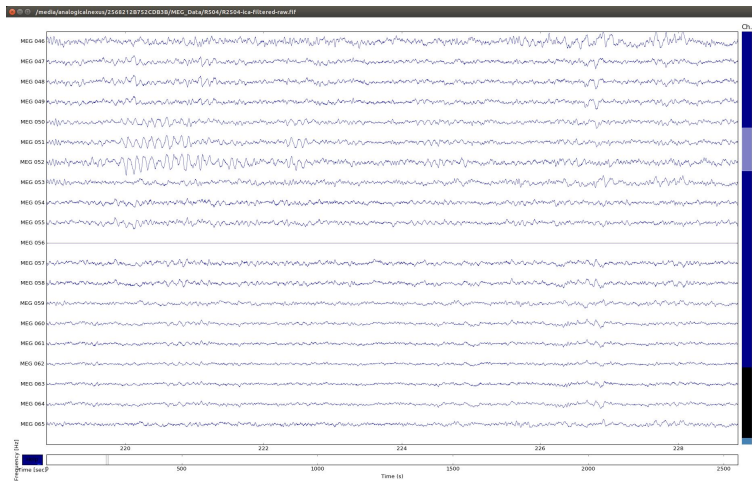
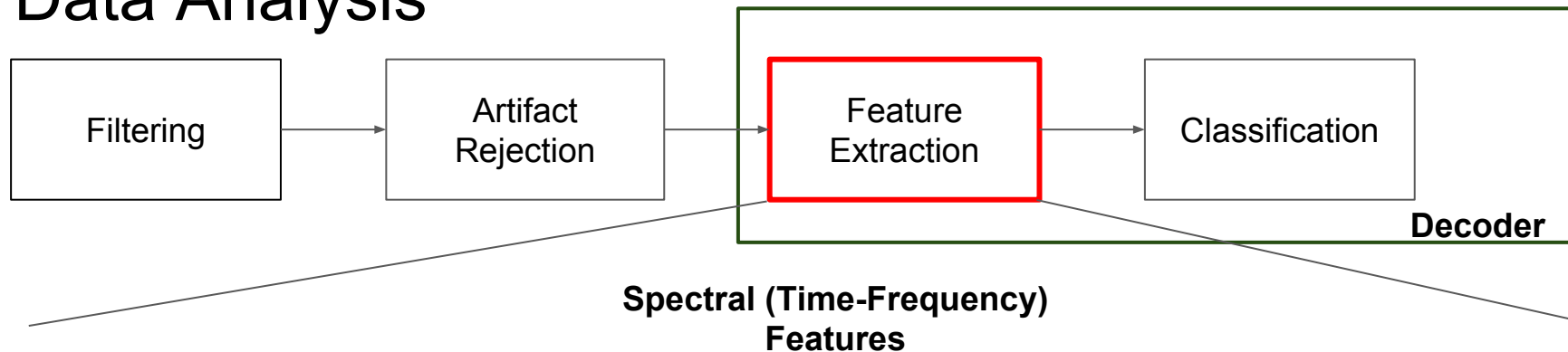
Average over 69.94ms - 82.10ms



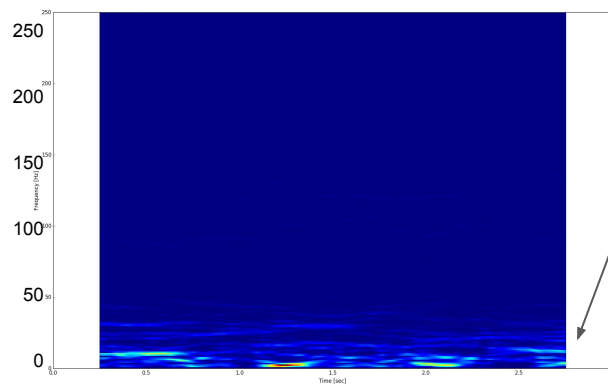
Average over 145.14ms - 153.16ms

Grand average evoked activity by Rhyme Probe

Data Analysis

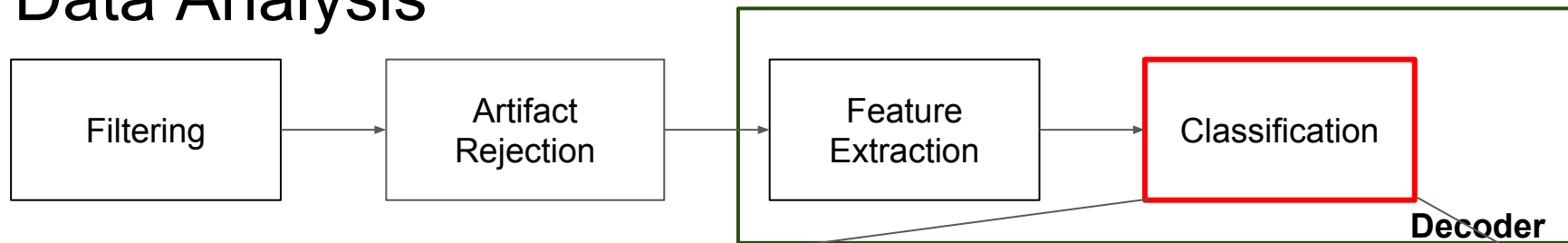


Fourier Transform

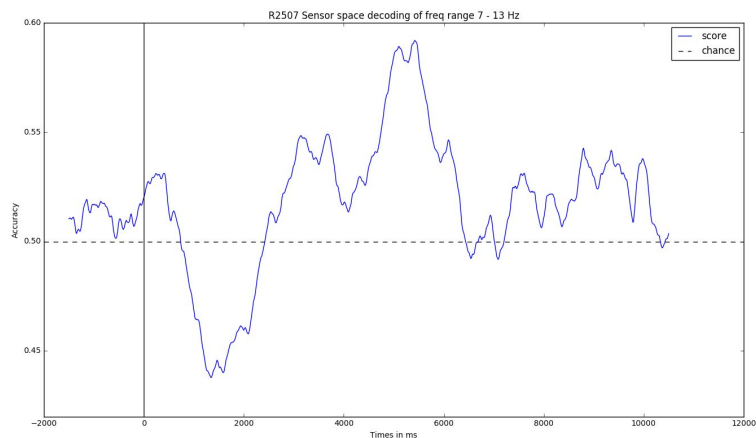
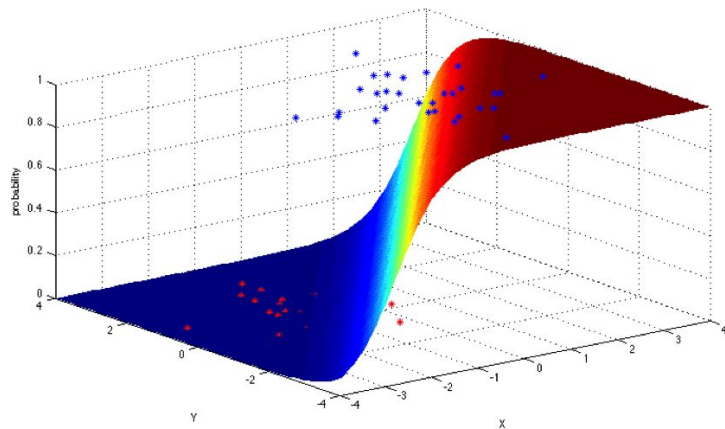


delta(1-3Hz)
theta(3-7Hz)
alpha(7-13Hz)
beta(13-22Hz)

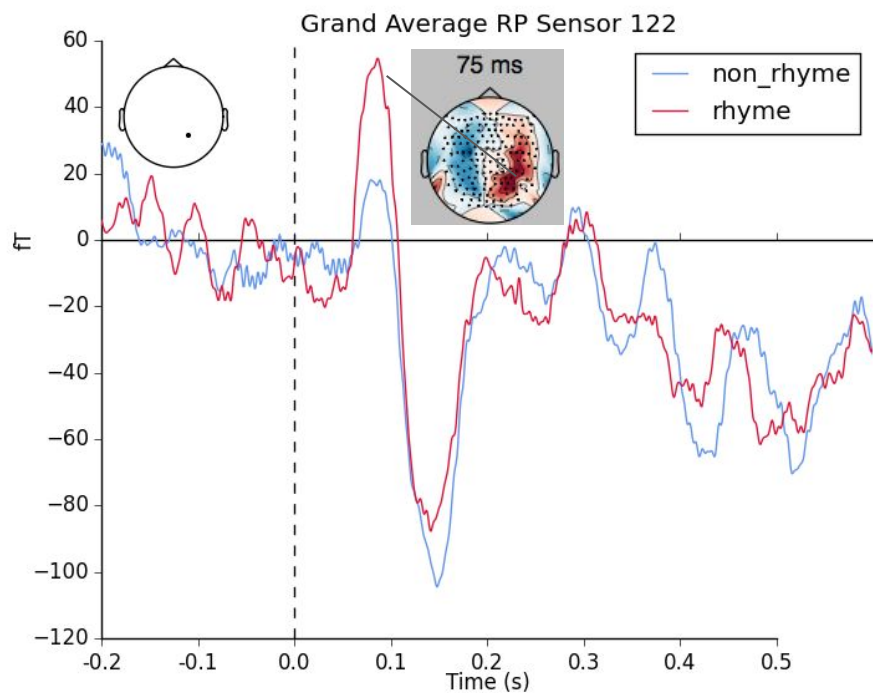
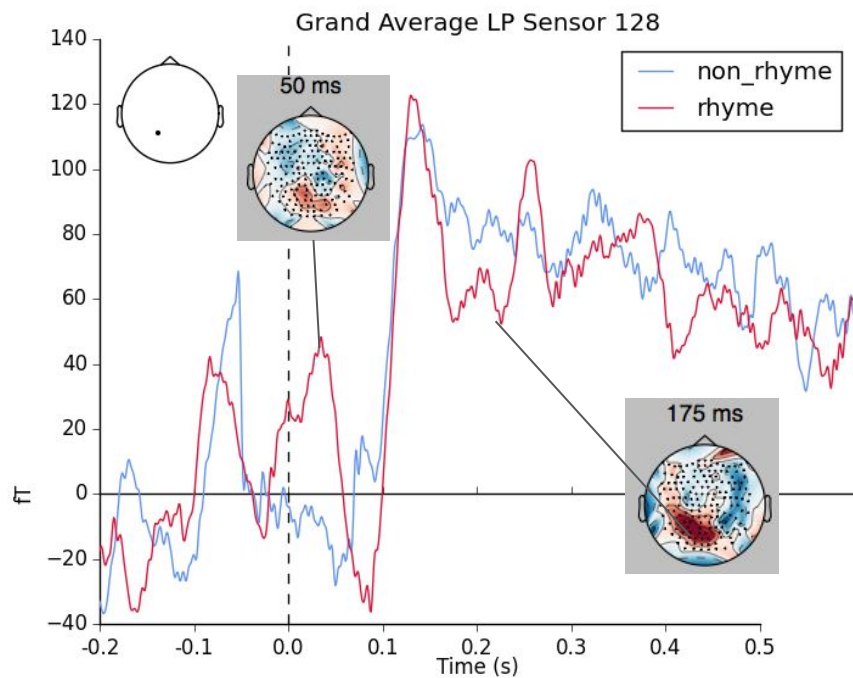
Data Analysis



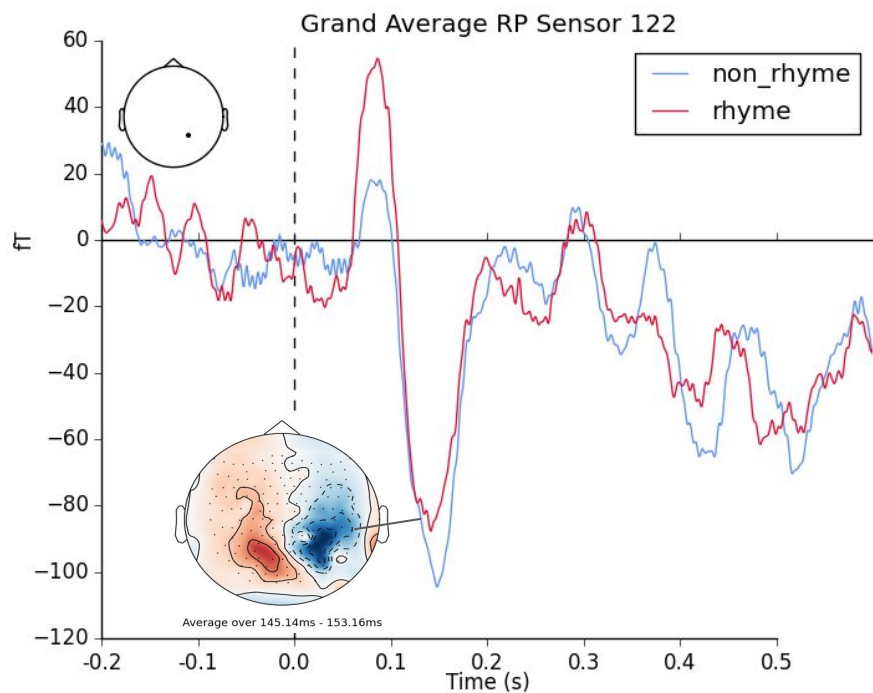
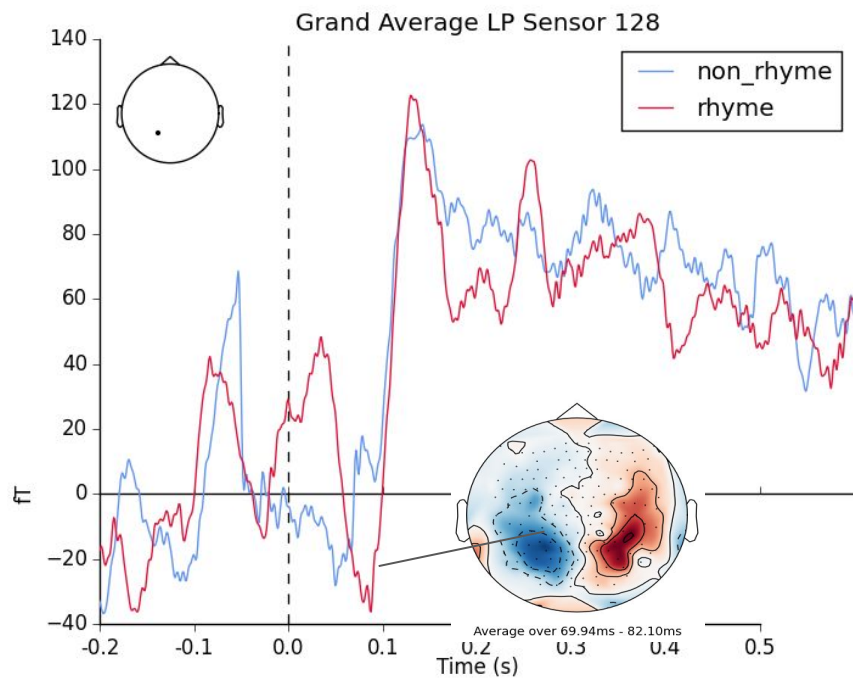
Logistic Regression



Grand average evoked by Rhyme Probe

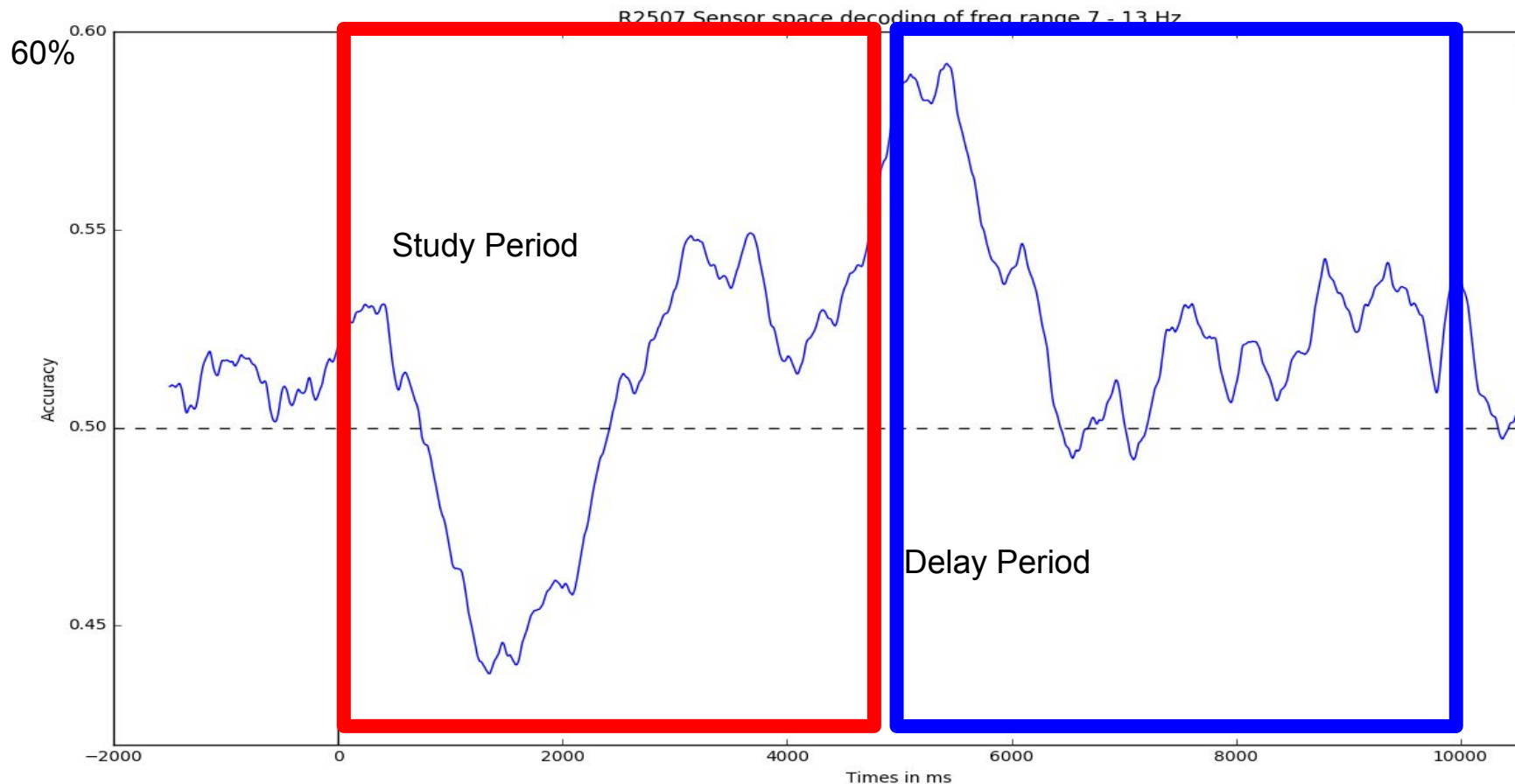


Grand average evoked by Rhyme Probe



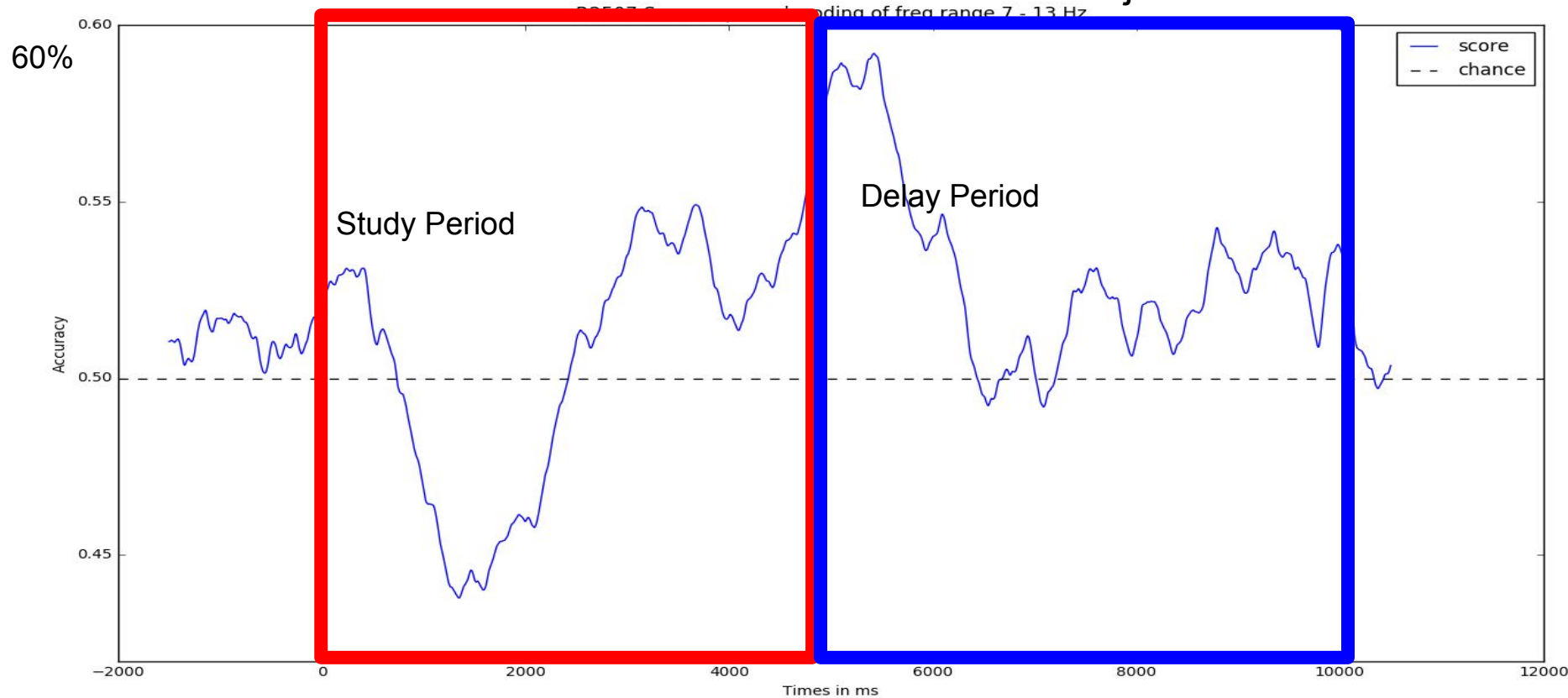
Alpha

Subject 2507



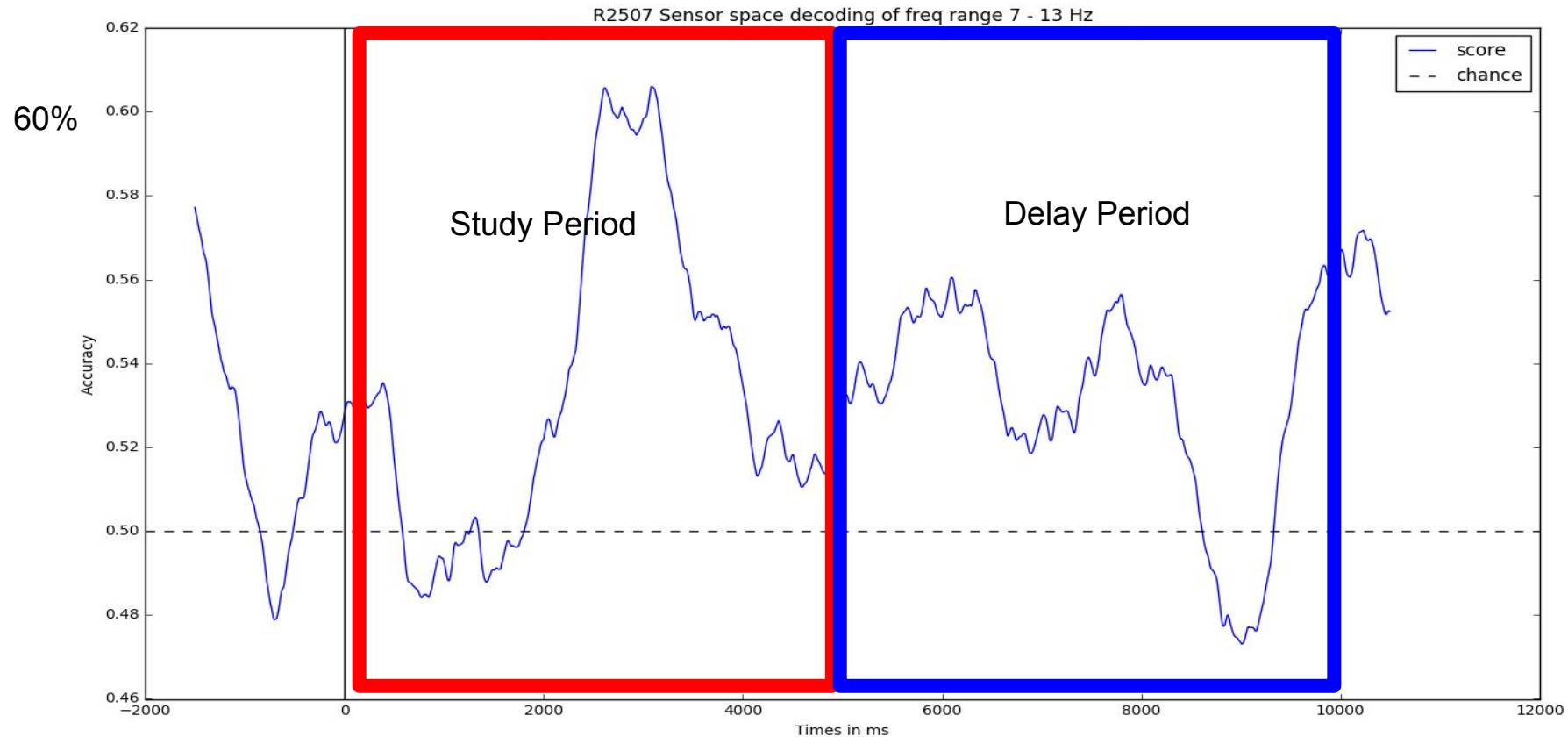
Alpha Left Hemisphere

Subject 2507



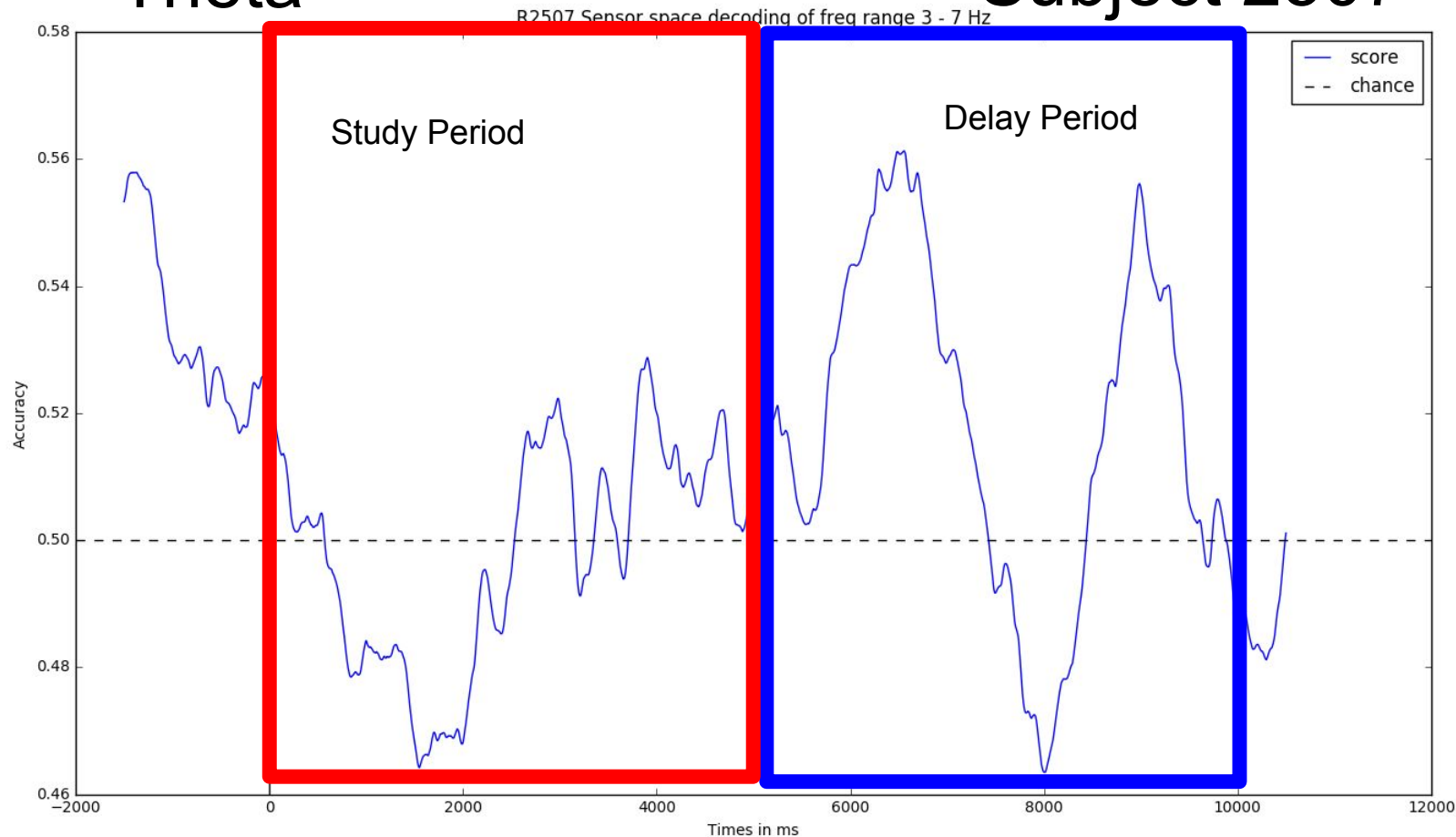
Alpha Right Hemisphere

Subject 2507



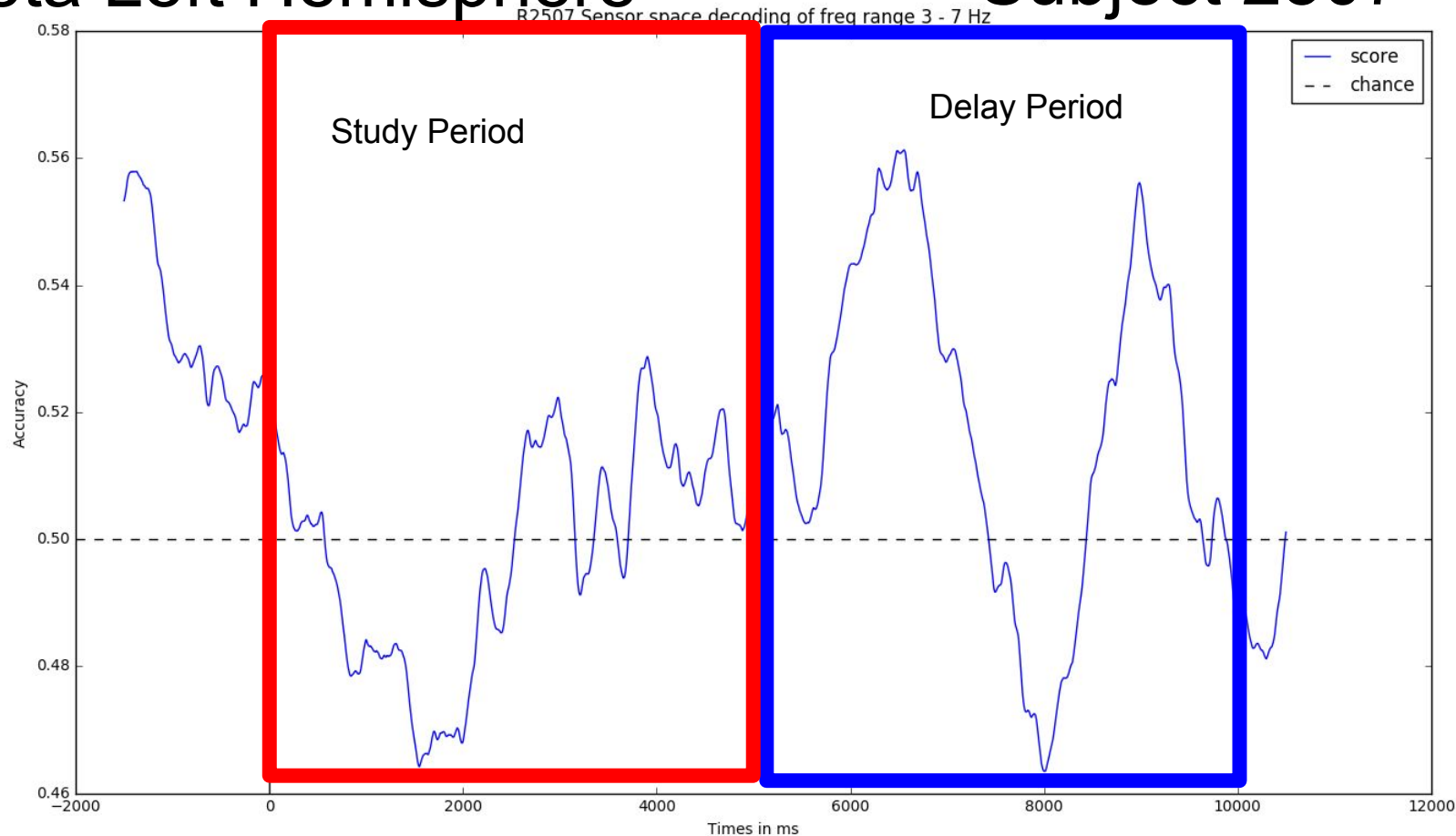
Theta

Subject 2507



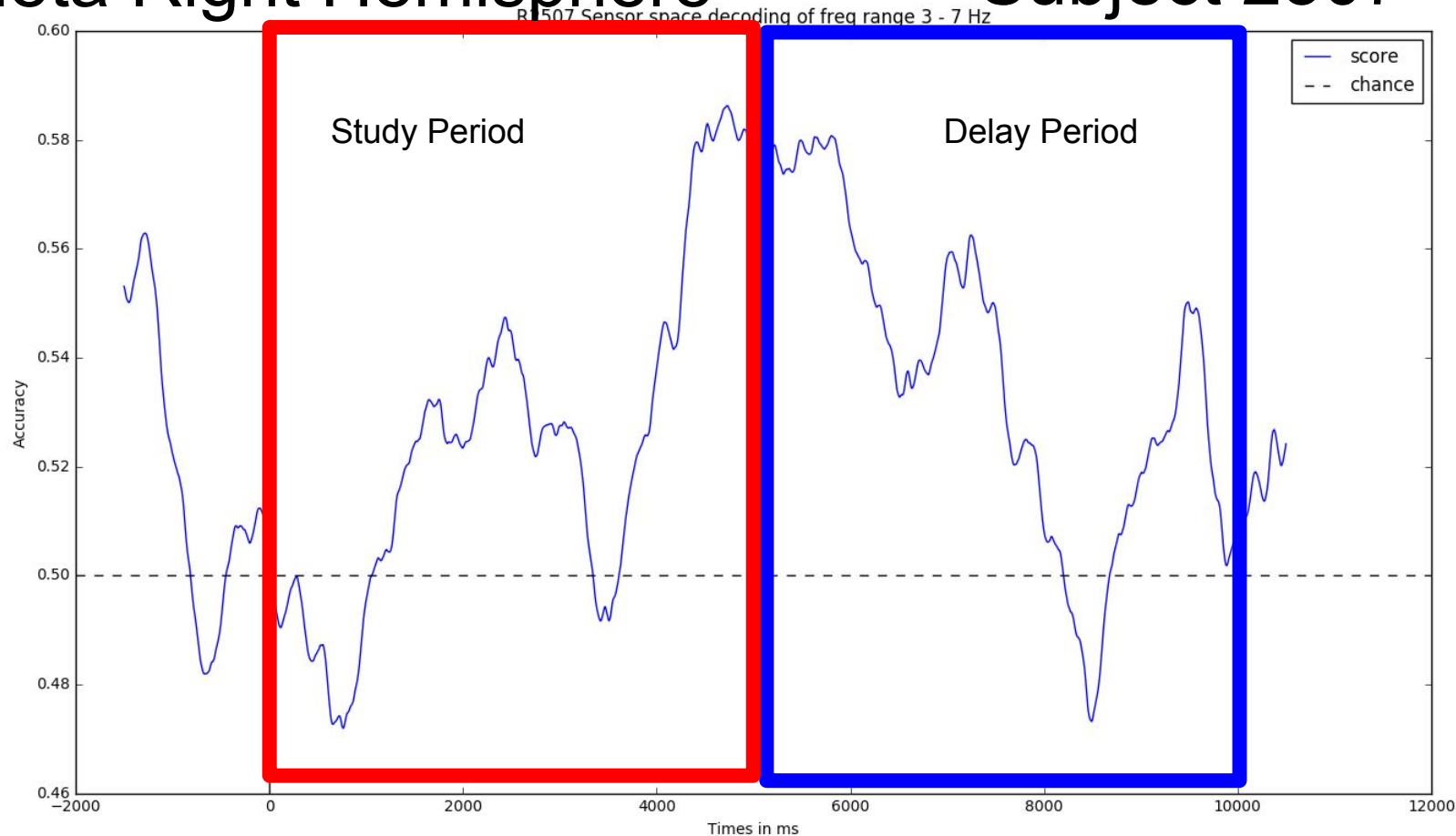
Theta Left Hemisphere

Subject 2507



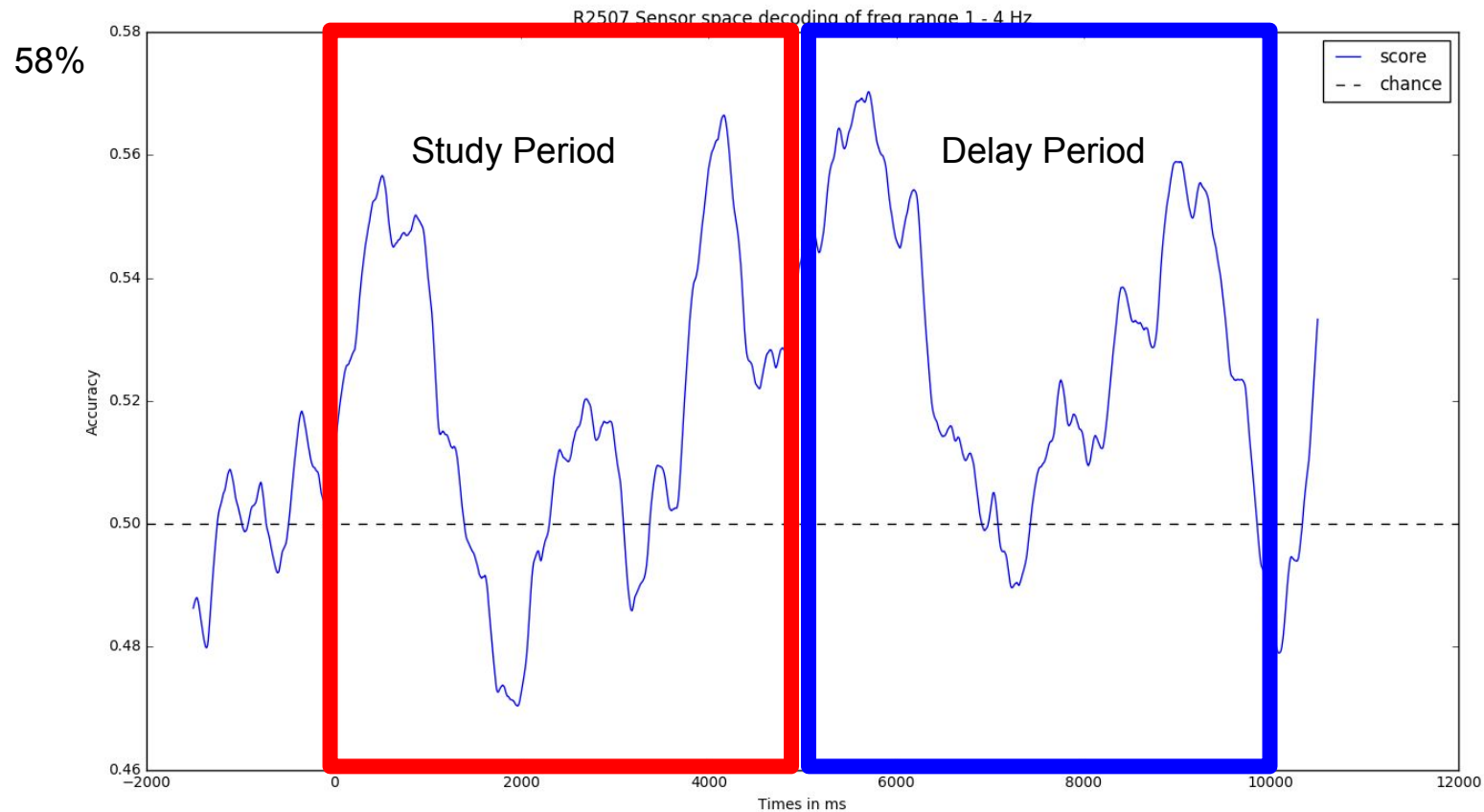
Theta Right Hemisphere

Subject 2507



Delta

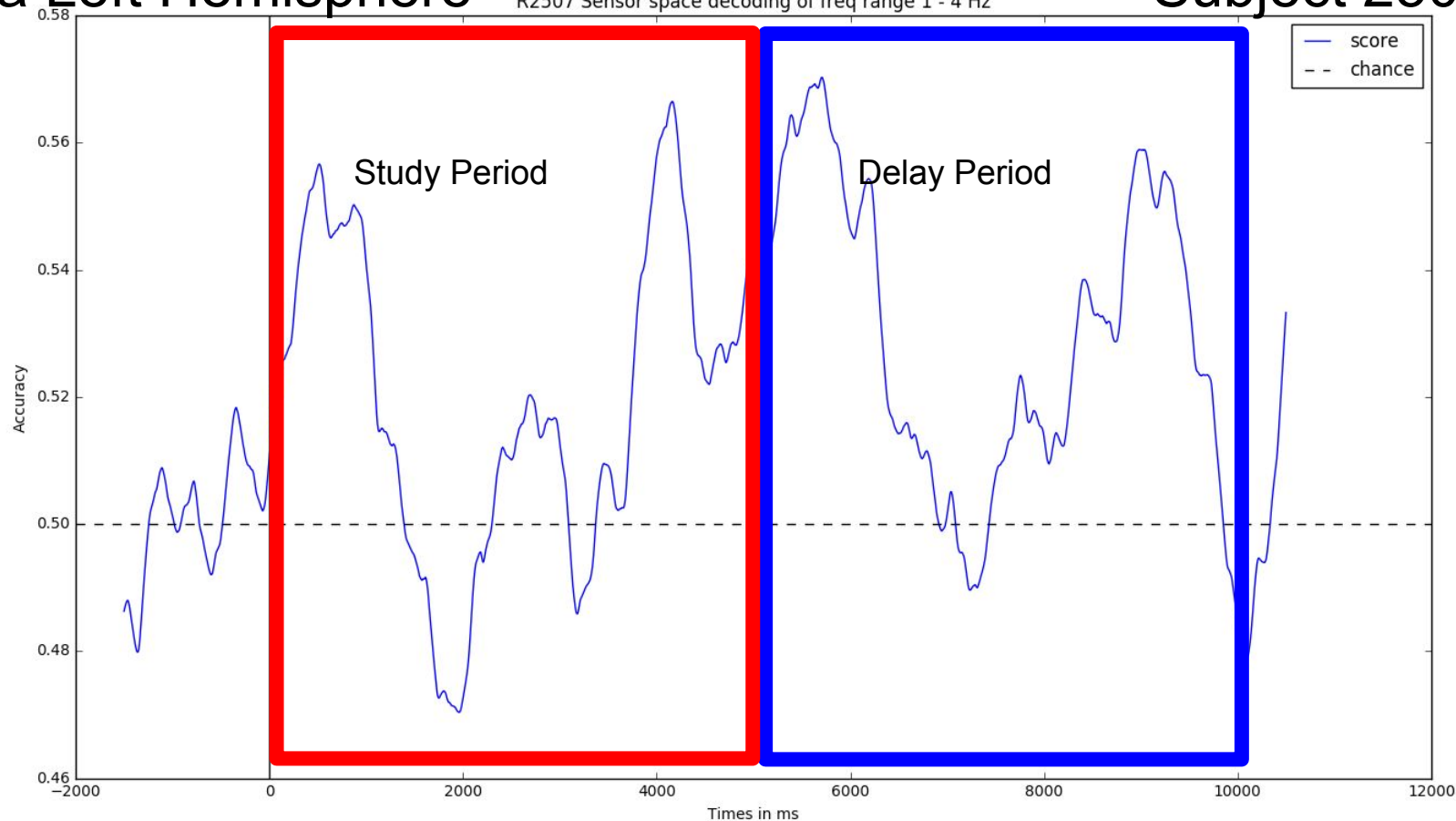
Subject 2507



Delta Left Hemisphere

R2507 Sensor space decoding of freq range 1 - 4 Hz

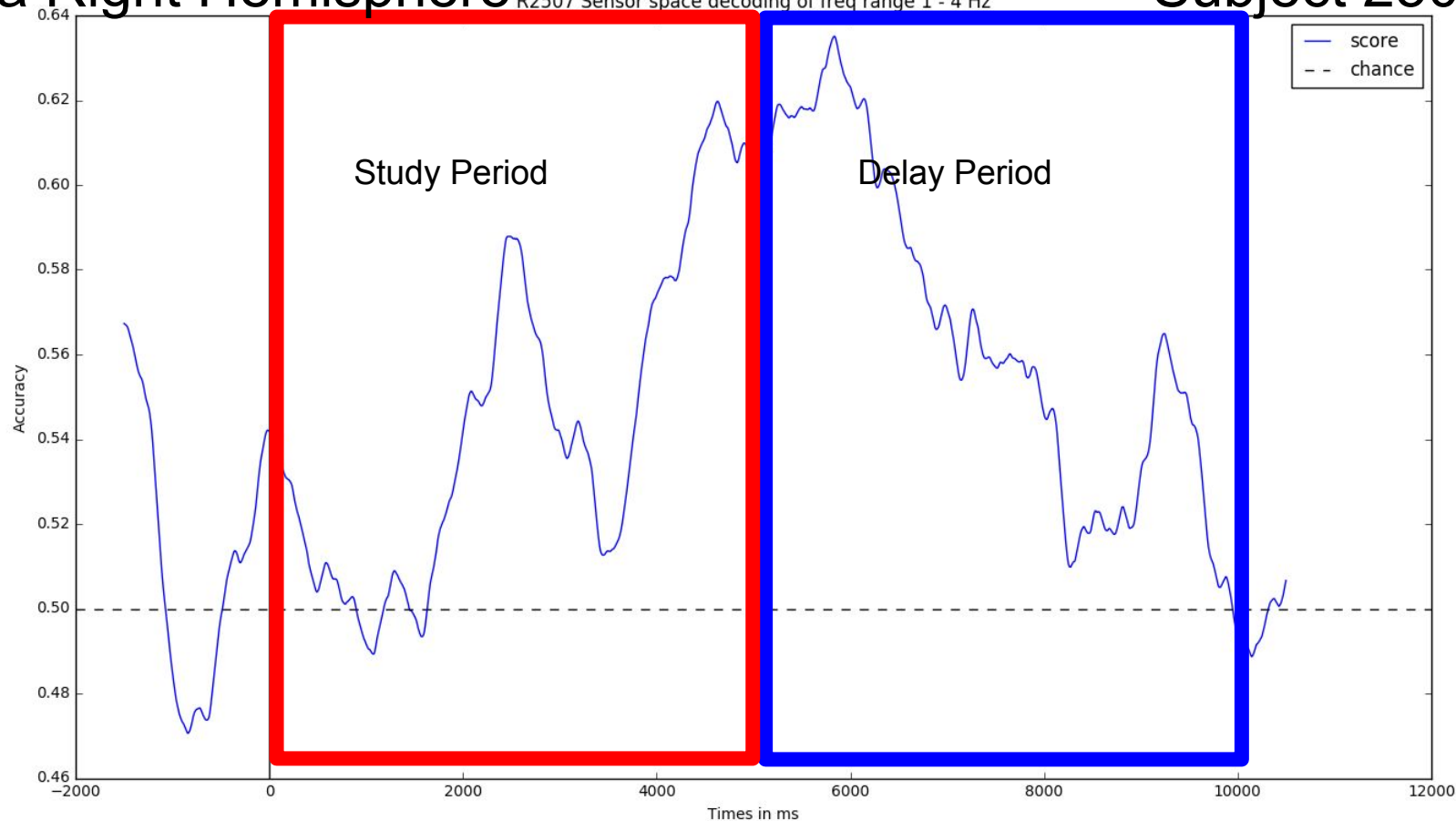
Subject 2507



Delta Right Hemisphere

Subject 2507

R2507 Sensor space decoding of freq range 1 - 4 Hz



Results: Syllable Decoding (1 vs 3)

Max Classifier accuracy in Delay period

	Delta (1-4)	Theta (3-7)	Alpha (7-13)	Beta (13-22)
R2499	< .5	<.55	<.55	~.5
R2501	<.55	<.6	<.6	<.6
R2504	<.55	<.55	<.55	<.55
R2505	<.6	<.6	<.55	<.6
R2507	<.6	<.6	~.6	<.6

Results: Word Nonword Decoding

Max Classifier accuracy in Delay period

	Delta (1-4)	Theta (3-7)	Alpha (7-13)	Beta (13-22)
R2499	<.6	<.6	<.6	<.6
R2501	*	*	*	*
R2504	~.55	<.55	~.55	<.55
R2505	<.55	~.55	~.55	~.55
R2507	~.55	~.5	<.55	<.6

Summary and Conclusions

1. In some subjects we were able to predict Syllable length during the delay period
 - a. -Specific frequencies were better than others
 - i. Alpha, Theta

Hypotheses

If phonological loop works as Waters et al. (1992) predict, what will the articulatory rehearsal look like over the delay?

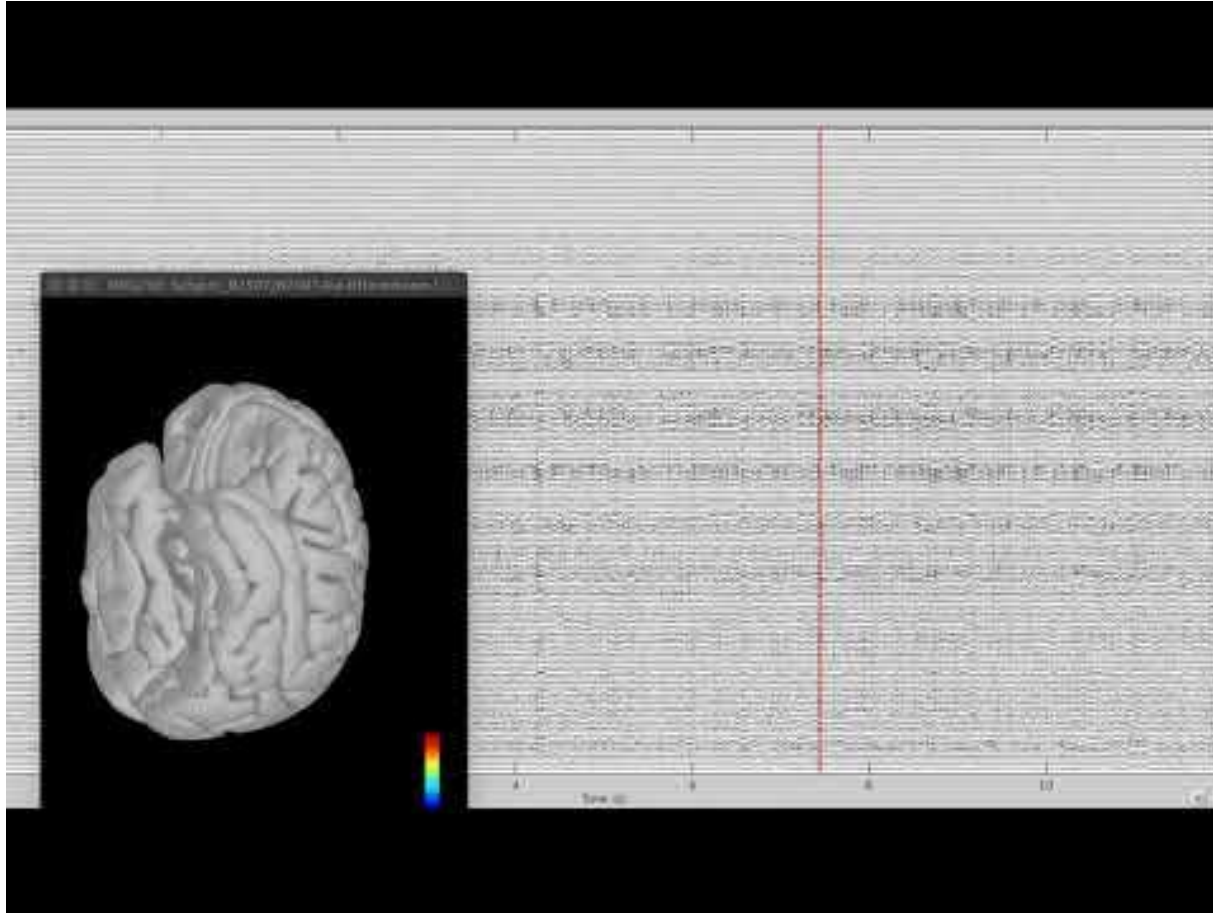
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2. Will there be differences based on load?
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Most

Yes

Not as much – task effect

Source Localization

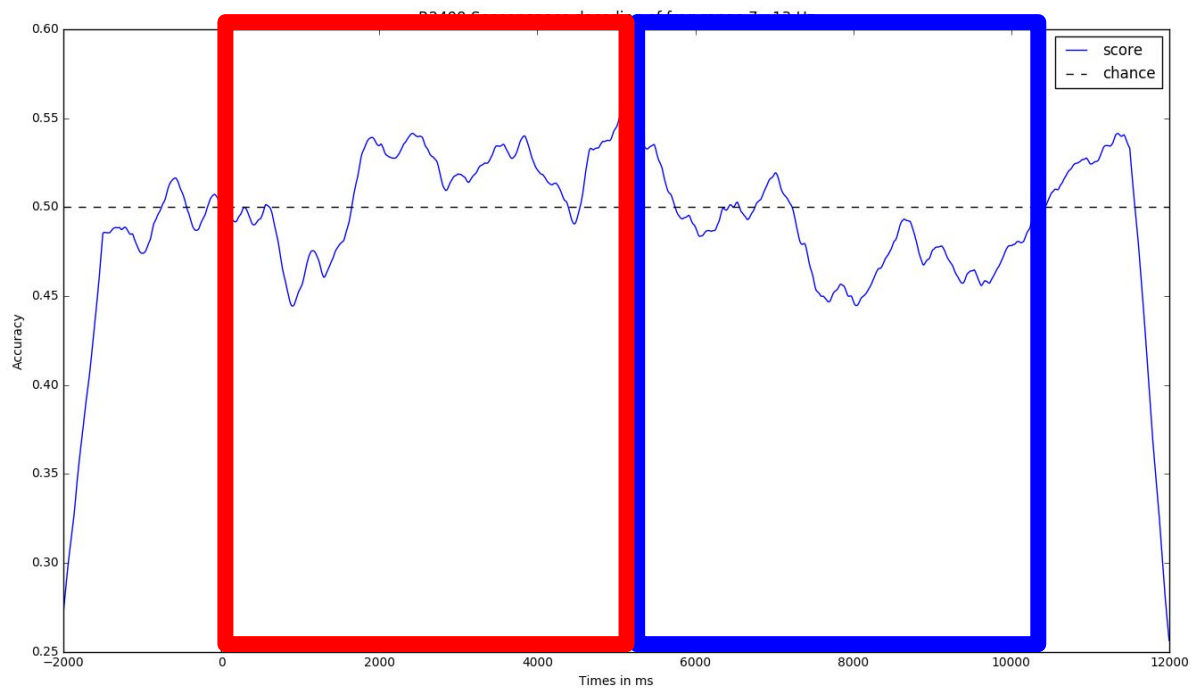


Future Directions/Limitations

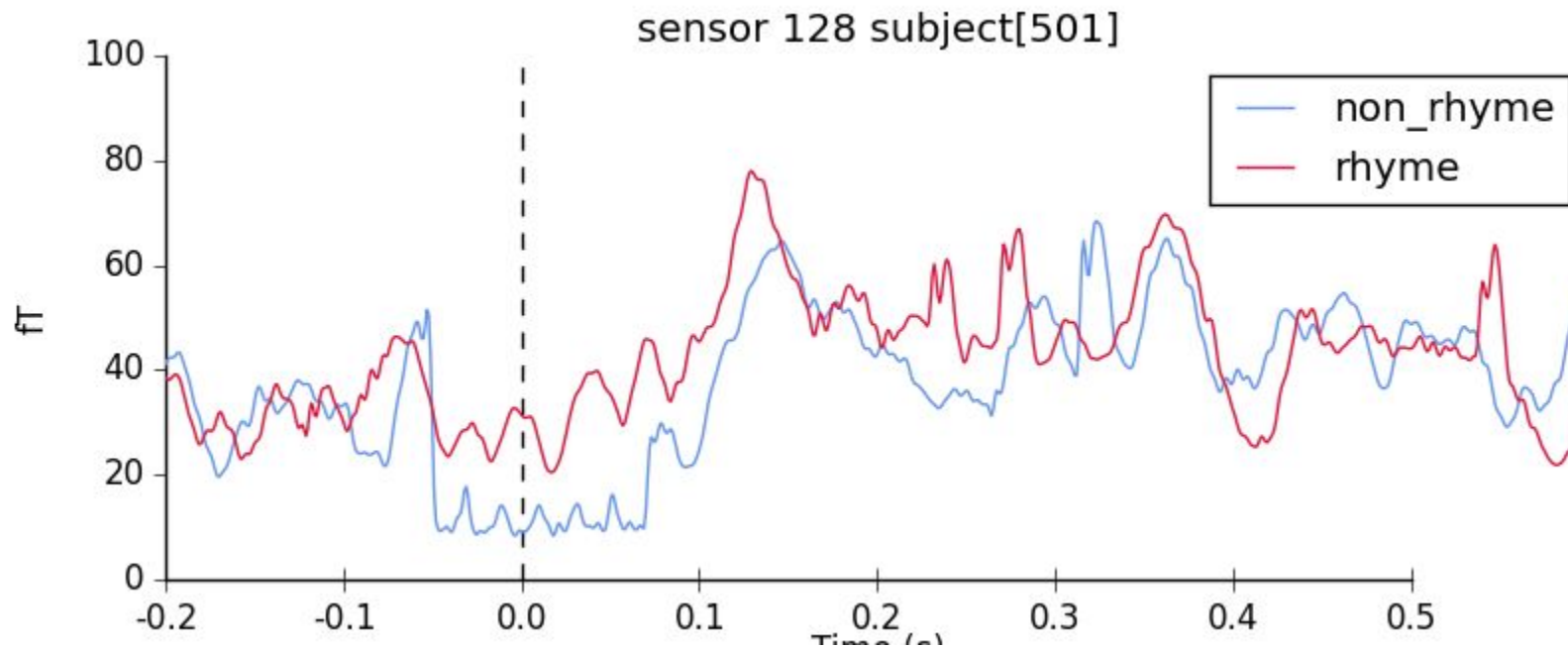
- Individual differences in task
 - Behavioral effects in future
- Trial numbers:
 - Interactions hard to analyze
- Rare Words
 - Weakened non-word distinction
- Processing power
 - Source localization
 - Decoding over specific ROIs
 - Decoding Higher Frequencies

Poor classification for R499

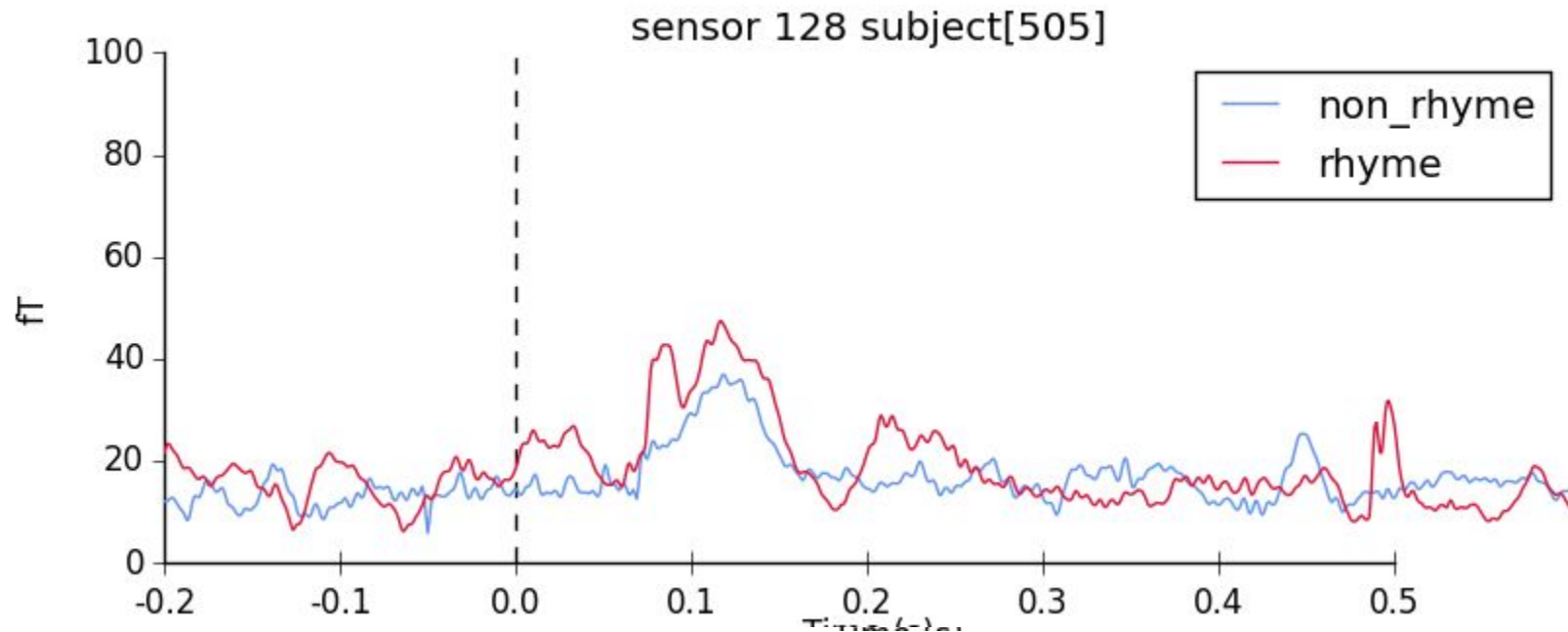
α



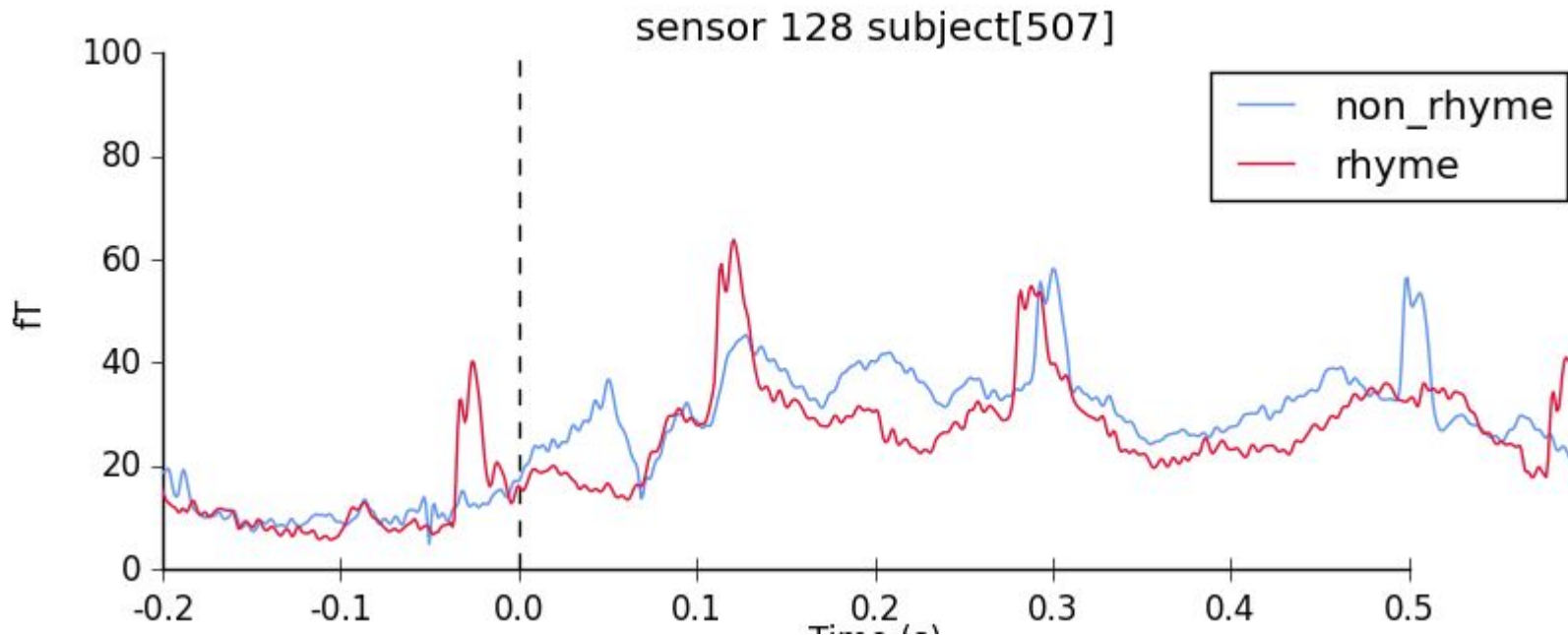
Poor classification for R499



Poor classification for R499



Poor classification for R499



Poor classification for R499

